

HISTORY - AGRICULTURAL ENGINEERING, USDA.

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH ADMINISTRATION
BUREAU OF PLANT INDUSTRY, SOILS, AND
AGRICULTURAL ENGINEERING

AGRICULTURAL ENGINEERING

BELTSVILLE, MARYLAND

October 24, 1951

To: All Technical Staff, Divisions of Agricultural Engineering

From: J. D. Long, Acting Director of Agricultural Engineering Research

Subject: FIFTY YEARS OF PROGRESS IN AGRICULTURAL ENGINEERING
~~History of USDA Agricultural Engineering Research~~

Attached is a mimeographed draft of the history of agricultural engineering research as it has developed in the U. S. Department of Agriculture. This has been compiled for presentation this week at the 50th Anniversary Seminar being held by our Bureau.

Naturally, we wish this history to be complete and accurate in all details. It should be made as interesting to read as possible. It should include every significant instance of the leadership we have provided, review each of the major contributions we have made to the physical betterment of farm living and list every possible example of the economic returns to the agricultural industry from our agricultural engineering research developments. The latter, expressed in dollar terms, are especially desired.

It will not be possible to include these in the presentation at the Bureau Seminar but we anticipate that copies of the revised history will be published for limited distribution.

You are requested to make corrections in this mimeographed copy, rewrite sections of it or write new paragraphs which will help give the complete agricultural engineering story. What have the results from your work, past or present, meant to the improvement of rural living, to the agricultural industry, or to our national economy? Technical men, especially those engaged in research, are not inclined to boast of their accomplishments and we do not wish this presentation to appear in that light. We do, however, request the assistance of each of you in making this a factual record of our work and accomplishments written in an interesting and persuasive manner.

Please give this your immediate attention. Send your revisions and additions to Robert B. Rathbone, Information Specialist of our Division, by December 1.

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF PLANT INDUSTRY
WASHINGTON, D. C.

January 10, 1915

All Technical Staff, Division of Agricultural Experimentation

Dear Sirs: I am very glad to hear of your interest in the work of the Bureau of Plant Industry and the Division of Agricultural Experimentation.

The Bureau of Plant Industry is a very important part of the Department of Agriculture and the Division of Agricultural Experimentation is a very important part of the Bureau of Plant Industry.

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Dawey Long

October 1951

FIFTY YEARS OF PROGRESS IN AGRICULTURAL ENGINEERING

Fifty years of progress in agricultural engineering have wrought a revolution on the farms of America. You, who can remember the farms of 50 years ago, when horsepower was measured in terms of horses--or the efforts of man himself--must realize how true this is.

One of the great agricultural engineers of our times, J. Brownlee Davidson, of Iowa State College, recalls the early 1900's as a period of extended prosperity for the farm people of America. This man, who has been a leader in his field since he became head of the Agricultural Engineering Department at Iowa State College in 1905, remembers that "there were incredible rumors of wireless telegraphy" at that time, and that "motion pictures were being demonstrated as a novelty." The Wright brothers had conducted some experiments with flying machines. The automobile, while so rare that many states had passed laws to protect horsemen against the nuisance, was in progress of development. Mud roads prevailed throughout the agricultural sections and railway travel was the only method to consider for anything but short distances.

"The horse had little competition as a farm motor. Steam tractors were in common use to operate threshing machines, and the gas tractor was looked on as an impudent intruder. The International Harvester Company, the first great merger of the farm machinery manufacturers, had been organized but a few years. Agriculture was becoming more and more prosperous."

Is it possible that in times such as those, that anyone--even such far-seeing men as Davidson--could envision the changes that were to come in so short a time? Could they have believed then that in 50 years so few workers on our farms could produce abundantly for our ever growing population? Just in the last 10 troubled years the farms of this country have increased production 21 percent--and without recourse to unexploited, virgin acres. Farm population through this period decreased by more than a million, until today less than 16 percent of our total population lives on the farm.

Could men in 1900 have predicted the extent of farm mechanization that has brought about this revolution? Did they see the possibilities of today's farmer handling his corn, grain, and forage crops from harvest to storage without a scoop shovel or pitchfork, or realize that he might feed and water his livestock with a press of a button?

Many of us who have crossed the half-century mark can remember a boyhood in a farm home that stood stark and square against the sky. The farm home in 1900 with central heating was a modern home. Running water--especially hot, running water--and sewage systems were rarities. Coal oil lamps furnished light, and cooking was done on a wood or coal stove. Refrigeration was only for those who could stock an ice house from a nearby river or lake during the winter. A pantry adjoining the kitchen usually housed the dining necessities--a big step-waster in terms of these days of the U-shaped kitchen.

Note - April 1964 - "about to come back"

THE STATE OF TEXAS

The State of Texas is a large and important state in the Union. It is one of the most fertile and productive states in the Union. It is one of the most important states in the Union. It is one of the most important states in the Union.

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Our modern farm home of today incorporates utility and beauty in its architecture; new materials and methods in its construction. Electricity is put to many uses and other sources of power are harnessed to make less work and more comfortable living for the farm family. Research agricultural engineers and architects have had much to do with this change.

The expansible farmhouse is a single example.. Plans for these fine, low-cost homes have been used by farm families in every state in the Union. They offer convenient attractive housing for the small family just getting started on the farm. As the family and income grow, rooms can be added with little remodelling and at low cost. The home retains its fundamental beauty and usefulness, stemming from good architecture and good planning.

A modern barn in 1900 was built of heavy, sawed timbers, mortised and tenoned together. Pens for livestock were made of wood and storage for corn, grain, and hay was included in the barn. The barn in those days was built primarily for horses, but the rats found the wooden floor a fine home. If a farmer was really up to date, he unloaded his hay from wagons with a fork operating over a pulley at the ridge of the barn.

The barn usually sat in the middle of a large fenced lot, so that if there were cows to be milked it meant several trips through the often-muddy lot carrying milk to the house to be separated.

Ground feed for the cows was often prepared in a sweep mill. A team of horses moving in a 25-foot circle provided the power, and the grain was hauled to and from the mill in bushel baskets. Few farmers piped water to the barn or the lots in those days. Cattle were usually watered from a large trough that was filled by hand from the pump. Most hogs were watered by bucket .

Compare this fine barn of its day with its present-day counterpart. Today's barn has rat-proof, concrete foundations and floors that are easy to clean. Better ventilation and temperature control, electric lights, constant water supply, automatic feed grinding and feeding devices, improved curing and handling have made the modern barn a place of high production with less labor. Barn lots are paved and lighted, and buildings are arranged for convenience and step saving.

Farm buildings in the United States in 1910 were valued at about \$6 billion. Today, the figure stands at nearly \$20 billion. This year, farmers were expected to spend more than a billion dollars for new construction and another \$800 million for repair and maintenance of their buildings.

The machinery story is much the same. At the turn of the century a farmer turned his soil with a walking plow, pulled by horses. A man using a 14-inch plow and two horses could till about two acres a day. Discing and harrowing were done with a team of horses and a man walking behind. Corn was planted with a horse-drawn planter, and much of the grain was seeded with an end-gate seeder, followed by a harrow.

The house was built in 1880 and was the property of the family of the same name. It was built on a hill and was the only house of the kind in the neighborhood. The house was built by the family and was the only house of the kind in the neighborhood.

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Corn was picked by hand and grain was cut with a binder, shocked, and usually stacked until threshed. Hay was cut with a horse-drawn mower, raked by a dump rake, loaded onto wagons by hand, and often unloaded in the same way.

The horse was at his hey-day in the early 1900's but his number was up. In 1901 the first tractor went into commercial production. In 1909, 2,000 tractors were manufactured. In 1913, when the heavy tractor began to be replaced by the 2-plow, small tractor, this form of power began to appear more frequently on the farms. By 1920 there were 250,000 tractors in use on the farms. Last year, that figure had grown to nearly four million.

The combine, too, tells the story of machines replacing man and beast on the farm. There were 6,000 of them cutting grain in 1920, 65,000 in 1930; and today 10 times that figure--650,000--are helping reap our bumper harvests.

Today, also, we have the corn picker, modern tillage implements, the sprayers and dusters that have replaced the hand hoe. The airplane is becoming another farm tool--controlling weeds, insects, and diseases; fertilizing and seeding from the air. Mechanical cotton harvesters are no longer unusual sights in the South and other hard-to-handle crops are being mechanized through agricultural engineering research.

The value of farm machinery in 1910 was \$2 billion. Now it is more than \$12 billion. One man on the farm today is doing the work that two could do 50 years ago.

Yet, the revolution is by no means complete. Even today only about 30 percent of our farm population have a bath or shower with running water. Only 45 percent have sinks. Eighty-eight percent have electricity, but many are making only limited use of this source of power.

Farmers are still spending too much of their time doing chores. Some crops are yet to be mechanized and improvement of current machinery must keep pace with our need for top production with limited labor.

We agricultural engineers are the newcomers to the ranks of organized agricultural scientists. "Organized" because agricultural engineering, and men practicing the profession have been with us for a long time. When our mutual ancestor knocked the corners off a flat stone so that he could transport his belongings from place to place on wheels, he did a piece of agricultural engineering research that has since been hailed as one of the greatest inventions of all times. There were other men at later dates, about whom we know more, who made great contributions to the world as agricultural engineers. Cyrus McCormick and John Deere are two who have their names in nearly every American history book.

* But organized agricultural engineering research, as we know it in the U. S. Department of Agriculture, awaited the turn of the century before it

made its first, small beginning. It was then, after the mad rush of many of our people to settle the West, that there came a clamor for help in the best use of irrigation waters on the fertile, but arid lands. It was in that period too, that the Federal government turned over much of the swamp lands in the public domain to the separate states, who, when they attempted to put the land to use, found they needed the knowledge of agricultural engineers to drain these vast areas. State Experiment Stations were getting established and they felt the need for engineering know-how, not only on their own staffs, but in a cooperative relationship with the U. S. Department of Agriculture. A depression in the middle 1890's brought a demand from farmers for more labor-saving machinery and equipment to replace the hired hands whose salaries they could no longer afford to pay.

Many thoughtful persons were shocked at the waste of top soil as thousands of acres were "farmed out" each year. The more outspoken of them called on the Government to help develop equipment and methods that would stop erosion--stop this ravage of our most important resource.

The Beginning of Agricultural Engineering Research -

These many economic farm needs, becoming increasingly important to the farmers and dependent city dwellers alike, finally brought the need for agricultural engineering research into sharp focus in the U. S. Department of Agriculture. Two popular publications issued in 1895 and 1896 were among the first signs of engineering research activity in the Department. One of these, "Silos and Silage," Farmers' Bulletin 32, was issued in 1895 and the following year "Sewage Disposal on Farms and Protection of Drinking Water," made its appearance as Farmers' Bulletin 43. That original farm sewage and water bulletin was the first of 12 USDA publications concerned with the subject, and during the 56 years since then well over 3 million such publications have found their ways to farms of America.

* Although Congress in 1890 set up an Office of Irrigation Inquiry in the U. S. Department of Agriculture, which ran a five-year course before it passed out of the picture, it was not until eight years later that agricultural engineering research really got underway. In the opinion of the late Samuel H. McCrory, who was associated with the Department as an agricultural engineer through much of its history, the research unit as we know it today had its start in 1898 when a Division of Irrigation Investigations was established in the Office of Experiment Stations.

Originally it was the duty of this Division to collect from agricultural colleges and experiment stations information and data concerned with irrigation, but as the work expanded it was realized that irrigation and drainage were inextricably tied together. In fact, men irrigating their crops were creating many drainage problems of extremely serious nature. Drainage was included in the irrigation work as early as 1902 although it

* was several years later before direct appropriations for drainage research were to come from Congress. The original appropriation amounted to only \$10,000. Elwood Mead was placed in charge of the research. Mead had graduated with degrees in civil engineering and agriculture from Purdue in 1882, and had become the first teacher of irrigation engineering in the United States at Colorado Agricultural College in 1886. In 1898 he took charge of the first irrigation research of the U. S. Department of Agriculture. He later became chief of the Bureau of Reclamation, Department of Interior.

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These small beginnings were barely underway when the Committee on Methods of Teaching Agriculture of the Association of American Colleges and Experiment Stations went on record for, first of all, better agricultural engineering instruction in the colleges (they called it rural engineering); secondly, for separate rural engineering departments in the colleges; for cooperative * research along these lines between USDA and the State Experiment Stations; * and finally, they recommended that Congress expand agricultural engineering research in the Department.

Stirrings of men carrying on agricultural engineering functions at state colleges and universities brought about the organization of the American Society of Agricultural Engineers in 1907--a group that has grown in importance and stature through the years, and has added impetus to the Department's research in this field from the very beginning.

The establishment of this group under Davidson, its first president, set the agricultural engineer on a professional plane equal to that of the other more established engineering groups. Its continuous work to improve professional status of agricultural engineering through the years has been closely allied with the Department's engineering research program. Several of our men have been honored with the presidency of the Association in the years past. Edmund B. McCormick, chief of the Division of Rural Engineering of the Office of Public Roads and Rural Engineering, was the first USDA engineer to become president. This occurred in 1917. McCrory held the position in 1923-4, A. P. Yerkes in 1937-38, S. P. Lyle in 1938-39, A. W. Turner, our present director of research, in 1943-4, and J. D. Long, assistant director of research, in 1945-6.

EGM- 1958-59

It is noteworthy too, that many of the men who have been associated with agricultural engineering research in the U. S. Department of Agriculture have attained one of the highest awards of their profession--winning either the Cyrus Hall McCormick or John Deere medal, which is given for outstanding service in the profession of agricultural engineering. These medals are presented at the annual meetings of the American Society of Agricultural Engineers.

* Since the first Cyrus Hall McCormick award was presented in 1932, five of the men who have had, or are having careers with our organization have been

honored. O.V.P. Stout, an irrigation engineer, received the first award in 1932; Mead, the first irrigation research engineer in the U. S. Department of Agriculture, won it in 1936; Charles A. Bennett, who is in charge of all cotton ginning engineering research of the Department, got the award in 1945, and Dr. E. G. McKibben, who is in charge of the U. S. Tillage Machinery Laboratory, Auburn, Alabama, was honored in 1949. A.P. Yerkes, an early machinery research engineer, was awarded the medal in 1950.

The first John Deere medal was awarded in 1938, and to McCrory, then chief of the Bureau of Agricultural Engineering. W. W. McLaughlin, who in the days of the Division of Agricultural Engineering, Bureau of Public Roads, headed the Irrigation Investigations, won the award in 1940; C. E. Ramser, a soil erosion research engineer, was honored in 1944; Frank Adams, an irrigation engineer, in 1947, and R. B. Cray, currently head of the Division of Farm Machinery, in 1950. *Ivan Wood, 1952. Wallace Ashby, 1958. W. V. Hill 1960. Samuel P. Lyle 1962.*

MBMA Award. T. E. Bond first winner, 1954

* In 1904 drainage investigations were officially included with the irrigation work and a Division of Irrigation and Drainage Investigations was established in the Office of Experiment Stations. At this time Congress appropriated \$67,500 for irrigation research and \$4,700 for drainage. Another step up was to come in 1908 when the work was divided into separate Divisions--a Division of Irrigation Investigations and a Division of Drainage Investigations. In that same period other slender beginnings were being made by the agricultural engineers. In 1903 the Office of Experiment Stations made studies in Florida and Georgia to determine if the use of underdrains would prevent hillside erosion. In 1905, the U. S. Department of Agriculture began a co-operative project with the Wisconsin and Iowa Agricultural Experiment Stations to investigate the value of reinforced concrete as a building material for farm structures, and for pipes, flumes, and drains. In 1906 the Division of Farm Management Investigations was established in the Bureau of Plant Industry and from 1908 to 1913, this Division carried on research with both farm machinery and structures.

As a matter of fact, it was these widely divergent beginnings of agricultural engineering research in the Department, and its late start, that has laid the pattern for its many ups and downs since that time.

The Consolidation of Agricultural Engineering Research -

* Many of the research bureaus of the Department carried out their own engineering research as the need arose, and not until the pressure for cooperation of the First World War came along did they give up many of these independent operations. The Bureau of Animal Industry was carrying on its own structures research; the Bureau of Chemistry was carrying on fire and explosion prevention and control research; and the Bureau of Entomology was developing its own spraying and dusting equipment.

Even after many of these diverse groups of engineers were brought together in a single Division of Agricultural Engineering in the Office of Public Roads and Rural Engineering in 1915, this trend continued. The Bureau of Plant Industry continued its own machinery research program and the Bureau of Markets carried on transportation, refrigeration, and structures studies.

Yet with all the slow and confused beginnings and the small appropriations and staffs, the engineers were getting a job done. Under the leadership of such men as Mead, Samuel Fortier, and S. G. Elliot they made tremendous gains in irrigation and drainage research. Fortier took over the irrigation work in 1907 after Mead's resignation, when Drainage investigations were set up in a separate Division at the same time. Elliot, a former president of the Illinois Society of Engineers, headed this work. Following his resignation in 1912, McCrory took over direct leadership of Drainage Research which he maintained until he was appointed chief of the Division of Agricultural Engineering in 1920.

The intensive cooperative irrigation research resulted in determinations of how much water was required for various crops, when it was expedient to put this water on the crops, and how soil types and topography affected the use of irrigation water. They also learned ways of reducing water waste, through better ditching, weed control, and land preparation. The California citrus growers alone claimed this research had increased the value of their crop more than \$4 million annually, without considering the better quality of fruit that they were raising.

Engineering drainage work, which was started as an examination and survey project in 1905, provided advice to many organized groups of farmers as well as individuals who desired to reclaim lands that were swampy or subject to overflow. It helped in the control of malaria in many areas. Their recommendations and active interest led to the reclamation or improvement of more than 105 million acres of land in the 15 years the project was supported by Congress. An out-of-the-ordinary assignment in 1907 resulted in a survey of the Florida Everglades, proving the feasibility of draining this area.

* * Much of the work of USDA agricultural engineers through the first quarter of this century was concerned with education and service as well as research programs. Until the Extension Service was established by Congress in 1914, the educational phases of agricultural engineering were considered as much a part of the work of these men as was their research. In fact it required nearly 10 years after the Smith-Lever Act was passed before all the educational functions were transferred to the Extension Service.

* In 1924, however, Lewis A. Jones, a drainage engineer in the Bureau of Public Roads, became the first part-time Extension Agricultural Engineer to work in close association with the research engineers. He was on the payroll of both the Extension Service and as a research drainage engineer. In 1929 S. P. Lyle became the first full-time Extension Agricultural Engineer to work with the men doing the research.

4 In 1915, the year that many of the divergent agricultural engineering units were gathered together in the Office of Public Roads and Rural Engineering, a field study concerned with the control of soil erosion, resulted in the publication of three bulletins which served as a handbook--almost a bible--for agricultural extension and experiment station workers and individual farmers in stopping erosion and reclaiming lost acres. Two of the publications were concerned with terracing and the other with reclamation and control of gullies. The research findings presented in these publications led to the establishment of more than 15 million acres of terraces in the United States, and the reclamation of thousands of gullies. After 1929, ten soil erosion experiment farms were located in principal erosion areas. Project work at these cooperative farms included terracing, dams, soil saving farm machinery, and requirements of machinery used on terraced lands. Even in those days--the early and middle 30's--when a dollar was considered worth almost 100 cents--it was estimated that terracing research alone had benefited land values an average of 8 dollars an acre. Although much of this research was lost to the Soil Conservation Service when it was organized in 1935, the basic groundwork had been laid upon which that organization could build a conservation program that has become common knowledge to almost every man, woman, and child in the United States.

It is noteworthy, that the engineers doing research in the U. S. Department of Agriculture have always been able to achieve much with very little. The original appropriation for Irrigation investigations in 1899 was only \$10,000. Today our appropriation is 1,310,850--only 3.2 percent of the total appropriated for research.

* In 1913, a small section of the Division of Farm Management which was carrying on engineering research for the Bureau of Plant Industry, was set aside to study farm housing. Two men--Architects W.A. Etherton and M. C. Betts, as head and assistant respectively--made up the staff. In the next year, 1914, two more men were added. W. R. Humphries began a study of farmstead layout, and Wallace Ashby, an agricultural engineer, was assigned to a study of farm service buildings. This was the beginning of what is today the important Division of Farm Buildings and Rural Housing, of which Ashby is the head. These men made field studies in various parts of the country, then returned to their office in Washington to develop plans based on the best practice found in the field, combined with good architectural and engineering design.

Much was done at the time, and is still being done to find ways for farm people to make their homes and buildings more comfortable and serviceable--but always with a small staff. Before World War I the personnel of this Division fluctuated between two and six persons; by 1931, there were nine on the payroll, and in 1936, 25 were employed in the Division. During World War II, special assignments and the armed services reduced the engineering staff to 10. With the establishment of new projects under the Research and Marketing Act following the war, the staff increased to about 40 persons. Today, there are 39 regular employees on the payroll. These few men and women today are working toward still better farm homes and

in farm structures

buildings. Not only is the farm home under continuous study to make it more comfortable and useful, but the engineers are determining the structures requirements that will furnish the best health and production conditions for dairy and beef cattle, hogs, and poultry in every part of the country. They are carrying on research to develop building materials that will prove superior to those in current use on farms. They are determining corn, grain, and seed drying and storage requirements which will allow American farmers to save the important percentage of their crops too often lost in handling and storage after harvest. They are developing better methods of handling and storing fruit in the Northwest and potatoes and sweetpotatoes in their primary growing areas. It is apparent that these men, and their talents and abilities, are still spread mighty thin.

* In 1915, when three divisions of agricultural engineering were established in the Office of Public Roads and Rural Engineering, appropriations were only slightly over \$215,000. Fortier, who had headed irrigation work with the Office of Experiment Stations since 1907, became chief of that Division in the Office of Public Roads and Rural Engineering. McCrory headed the Division of Drainage Investigations and E. B. McCormick was chief of the Division of Rural Engineering. "Rural Engineering" included studies of farm water systems and sewage disposal, farm machinery and equipment, and farm structures.

Although farm machinery research was moved into the Office of Public Roads along with structures research in 1915, the old Division of Farm Management Investigations of the Bureau of Plant Industry, which had included this work, was transferred to the Office of the Secretary of Agriculture that year. Along with the Division went Yerkes, who had been with the Bureau of Plant Industry since 1911. Yerkes made an outstanding record in the eight years he was with the Department, serving during the First World War as Farm Equipment Administrator and having a hand in the publication of 12 bulletins dealing with tractors, harvesting machinery, and fire fighting on the farm. In the meantime, the machinery engineers who were attached to the Office of Public Roads and Rural Engineering, conducted a cooperative project with the Bureau of Chemistry concerned with the prevention of dust explosions caused by threshers in the Pacific Northwest.

An early achievement was the development of a fire extinguisher that could be carried on the threshing machine and used to put out the fires. Later Elmer Johnson and A. M. Daniels, of the Division of Rural Engineering cooperated with David Price, on loan to USDA from the Bureau of Mines, to solve the problems of handling the smutty grain. They made recommendations to manufacturers that led to better grounding and ventilation of the machines which practically eliminated the threat of fire in threshing smutty grain.

* The First World War had a solidifying effect on agricultural engineering research. Because a shortage of personnel brought on a need for cooperation the other research bureaus of the U. S. Department of Agriculture

began to make more use of the engineers who were at the time manning the three divisions in the Office of Public Roads and Rural Engineering. Fortier, McCrory, and McCormick were still in charge of all agricultural engineering research. In 1917 the engineers were called upon to design a compressed air sprayer for use in the Bureau of Plant Industry research. In that same year they designed a combined storm-water and sanitary sewer for the Bureau of Plant Industry at the Arlington, Va. Experimental Farm and designed and supervised the construction of a color laboratory at that farm for the Bureau of Chemistry. In 1918 they were called on by the Bureaus of Plant Industry and Entomology to prepare specifications for the rental and purchase of farm machinery.

Machinery engineers in the Division of Rural Engineering authored a series of war-time Farmers' Bulletins under the general title of "Care and Repair of Farm Implements." These were concerned with such subjects as "Plows and Harrows," and "Mowers, Reapers, and Binders."

Betts gave much of his time to the War Industries Board, directed by Bernard Baruch. While the appropriations for drainage and irrigation remained almost constant during the war years, money for structures and machinery research increased from \$12,305 in 1916 to \$25,000 in 1918. In 1918 the Office of Public Roads and Rural Engineering became known as the Bureau of Public Roads and although the status of the engineers did not change, their work was expanded in 1920 when they were given the job of reworking and distributing surplus war explosives. None of the picric acid, sodium nitrate, TNT, smokeless powder, nor 90 million blasting caps they found on their hands were suitable for commercial use. Although McCrory was in general charge of the project, George R. Boyd, who today heads our Division of Mechanical Processing of Farm Products, was given the job of converting and distributing these materials so that they could be used by other governmental and state agencies and by farmers for agricultural blasting. This he did. He developed formulas for modifying the various explosives, was responsible for their safe storage prior to delivery to contractors, was in charge of the supervision of manufacture at various contractors' plants and cooperated with the Extension Service in the distribution of the explosives. One of Boyd's jobs was the contracting of the reprocessing and shipping of 120 million pounds of smokeless powder, valued at more than \$8 million--the biggest peace-time contract for explosives consummated up to that time. It is estimated that the total saving through the re-use of these surplus explosives amounted to some \$30 million.

In the meantime engineering research in normal veins was moving ahead in the fields of drainage, irrigation, machinery, and structures. In 1917 a cooperative project with the Bureau of Plant Industry was begun concerned with the design of sweetpotato storages. Although less than \$800 a year was spent on this work--the total expense of the project was under \$10,000--the research resulted in improved farm and trackside sweetpotato storages that reduced losses which at times ran as high as 50 percent to

an average of less than 10 percent. The engineers were able to design structures in which temperature and moisture conditions could be controlled without expensive mechanical equipment. Also in 1917, Johnson headed a cotton dusting equipment project at Tallulah, La., carrying out experiments to devise insecticidal application equipment for both airplanes and ground machines. The year that research got underway weevils destroyed 25 percent of the cotton crop. This was the first research effort along these lines, and it laid down many of the fundamental concepts that have been built upon through the years, until today crop dusting and spraying are common on most farms, and are big business to insect and disease control organizations.

Shortly after the end of World War I, the engineers cooperated with the Bureau of Plant Industry in studies of transportation of fruit and vegetable crops. W. V. Hukill and S. J. Dennis assisted in developing instruments for these studies, including remote reading anemometers that made it possible to study air movement in a loaded refrigerator car. Hukill built a calorimeter and measured the heat of respiration of typical fruits and vegetables, a work he helped report in Technical Bulletin 771, "Calorimetric Measurement of the Heat of Respiration of Fruits and Vegetables."

Likewise a research project in dairy barn ventilation, started in 1921 with M.A.R. Kelley in charge, resulted in immediate benefit to dairymen and the public. The control of temperature and drafts through proper ventilation reduced sickness in high priced dairy herds, brought a higher level of sanitation to the dairy farm, and resulted in high production among milk cows. Results were published in USDA Technical Bulletin No. 591, "Relation of Stable Environment to Milk Production." Other phases of animal shelter research have been carried on continuously to the present time. Following World War I, Kelley also made extensive field studies of grain storage in the Middle West and western states, and published two bulletins, Farmers' Bulletin 1636, "Farm Bulk Storage for Small Grains" and Farmers' Bulletin No. 1801, "Corncribs for the Corn Belt." Both had wide distribution.

* The period shortly after the First World War also saw the beginnings of electrification research by agricultural engineers. Daniels, of the Division of Rural Engineering of the Office of Public Roads, wrote the first reports concerned with farm electrification. These appeared in the U. S. Department of Agriculture yearbooks of 1918 and 1919. In 1923, when the Department became a member of the Committee on the Relation of Electricity to Agriculture, McCrory was named as a Department representative. He also served as the USDA member of the Maryland Committee which operated the National Rural Electric Project in Montgomery County, Md., from 1928 to 1933.

The Division of Agricultural Engineering -

Other honors and duties fell on McCrory at this time. Although he had been in charge of over-all work of the engineers in the three Divisions in the Public Roads organization, he was made Chief of the Division of Agricultural Engineering, embracing all of this work, when it was established in the Bureau of Roads in 1925. In 1926, the Division of Agricultural Engineering was expanded. In addition to the Irrigation Investigations, Drainage Investigations, and Surplus War Explosives works, Structures, and Mechanical Equipment were established as separate projects and new additions included Plans and Services, administration of the Division, and advice and assistance to other government agencies. Total appropriations, a bulk sum for the first year of operation as a Division, was \$222,170. Later in 1929, Farm Land Development was set up as a separate project with an appropriation of \$12,000, and in 1931, an appropriation of \$65,000 was made for Cotton Ginning research.

During the six years that agricultural engineering research was carried in McCrory's Division of the Bureau of Public Roads it continued to expand, bringing forth the value of engineering research more and more. In 1924 the engineers began research on fertilizer distributing machinery at the request of the National Joint Committee on Fertilizer Application. At first, this work was concerned primarily with a determination of the physical characteristics of fertilizing materials when they were exposed to different weather conditions, and to investigations of different types of distributing machinery to learn how they would perform with different fertilizers under different field conditions. This information was published in USDA Technical Bulletin 182 in 1930 and is still looked to for basic information on drilling properties of fertilizer materials and on the performance of fertilizer distributors under farm conditions. Kelley began this work, developing a constant temperature control room to simulate all types of field conditions in the fertilizer tests. The next year Gray, who now heads the Division of Farm Machinery, took over. G. A. Cumings was made head of the project in 1927 and is still directing this research. In 1929, 22 fertilizer distributors and planters with fertilizer attachments were tested in field and laboratory for planting cotton in South Carolina to determine the characteristics of each machine. It was from this project that the research men came to realize that proper placement of fertilizer in relation to crop seed had great importance, and it was on this basis that the fertilizer project of the agricultural engineers was rewritten in 1931 to be concerned primarily with placement studies. Through 1950, 774 fertilizer placement experiments had been conducted with 41 crops in 28 states.

The project had not only led to the development of many types of fertilizer placement machines which have been adapted to commercial standards, but has resulted in definite recommendations concerning the fertilization of most of the common commercial crops grown in the United States. What this has meant in increased production per acre of all of these crops would show

wide variance, but the overall effect through the years could only be tremendous. This research has taught farmers how to use fertilizers. It is seldom these days that a man loses his crop to improper use of chemical fertilizers. In the early days of this research, however, farmers' lawsuits against fertilizer companies and dealers were common.

A short-lived engineering project, which only ran five years--from 1924 to 1929--resulted in nation-wide thanks for the man who did the research. A. H. Senner made a thorough study of domestic oil burners during that period in cooperation with the Bureau of Home Economics, and published his findings in Technical Bulletin 109, "A Study of the Oil Burner as Applied to Domestic Heating." This publication, a classic in its field, for the first time set down answers to the public's and manufacturers' problems concerning oil burning heaters. Senner analyzed the types of burners, pointing out the desirable and undesirable features of each; he scientifically considered the possibilities of switching from another fuel to oil; and he determined comparative costs of oil and other fuels. The bulletin gave the public a realistic picture of oil burners for home use, and it gave manufacturers a set of standards that resulted in the modification of most of the burners then on the market.

In 1926, potato storages were brought under the scrutiny of the agricultural engineers in a project that is still continued today. Betts, of the Division of Structures, headed the project in its original phase--a study of Maine potato structures--but in 1931 A.D. Edgar took over the project. He is currently working at the Potato Research Center, East Grand Forks, Minn.

Early work of the engineers on the project led to the development of a new type potato house that replaced most of those then in use in the heavy potato producing areas. The new houses offered better temperature and moisture controls, resulted in less damage to the potatoes, and increased the life of the structure. The work reduced potato spoilage more than half, and it improved the quality of potatoes reaching the market.

Edgar lacked funds to make studies under controlled conditions in the early days of this project, but, instead, he was forced to seek the cooperation of storage owners in making his tests. Even under these conditions, however, it was not long before he was able to point out ways of improving the storage to the owners. They found his suggestions making money for them. His constant attention to this work of improving standing structures and seeing that better ones were built to replace the outmoded has resulted in a valuable contribution to the late potato growing areas of the U. S. and Alaska.

* In 1928, sugar beet machinery was brought under research headed by E. M. Mervine. This led to cooperative set-ups with California from 1932 to 1943 and with Colorado from 1931 to 1943, which, after a year's inactivity, were re-instituted at Colorado and Michigan. Upon the death of Mervine in

1946, S. W. McBirney, who had worked on the project since its inception, took charge. McBirney was put at the head of the weed machinery investigation work in 1951 and George W. French took over the sugar beet machinery studies, headquartering at East Lansing, Mich. An early achievement of the engineers on this work was the development of a mechanical cross blocker for thinning sugar beets. Commercially adaptable, the blocker proved that it would reduce hand labor 30 percent, which at that time was 65 percent of the entire total beet production cost. This project has also been instrumental in aiding machinery manufacturers to place three different makes of harvesters on the market. The beet topping device developed on the project was incorporated in one of the commercial designs. The project engineers also conducted planter research that has resulted in the use of sheared seed, further developed by the University of California.

In 1930, a study of sugarcane land drainage in Southern Louisiana proved the value of deep ditches as compared with the numerous shallow ditches then commonly used. Deep drainage, as it became a common practice in that area, added an average of 10 to 15 percent to the annual sugarcane yields-- in some cases yield improvement ran as high as 40 percent. Sugar content of the cane was likewise improved by water drainage.

In 1927, the European corn borer clean-up campaign was inaugurated, and Government agricultural engineers were called in to take charge of the engineering phases of the work. They organized the operation and maintenance of the equipment and supervised demonstrations of clean plowing and low cutting of corn. At the same time research work was initiated in this field. This work was headed by Gray, who was assisted by several engineers still with the Division of Farm Machinery. These included Frank Irons and O. K. Hedden, who are presently located at the Spraying and Dusting Machinery Laboratory at Toledo, Ohio; V.D. Young, who is cooperating on aerial spraying and dusting work in Oregon; A. H. Graves, now working on potato machinery at East Grand Forks, Minnesota; D.A. Isler, who is at Beltsville, Maryland, working with the Forest Insects Division on aerial spraying and dusting; McBirney, now in charge of weed control machinery research at Columbia, Missouri; and I. F. Reed, project leader for oil crops production equipment, located at Auburn, Alabama. Also working with Gray at the time were Ashby, who now heads the Division of Farm Buildings and Rural Housing, and L. S. Schoenleber, currently with the Division of Farm Electrification.

Accomplishments of their research included the development of a low-cutting attachment for a corn binder, with which farmers could cut the stalks at ground level, and destroy the borers by running the stalks through a shredder, silo filler, or by burning them. These low-cutting attachments proved so satisfactory that all four of the manufacturers then building corn binders, placed attachment packages on the market selling for \$10.

The engineers also developed a trash guide which would allow a plow to completely cover all surface trash including the corn stalks, and a four-bar side rake, which proved superior to the regular three-bar rakes when used for raking stalks into a windrow after they had been cut with a sled

knife cutter (also developed through their research). The four bar idea took hold. There are still many machinery manufacturers who design their rakes with four bars which offer gentle raking action, shattering less of the leaves of forage crops. The engineers also developed and patented a lifting attachment for corn binders, which erected stalks that had been knocked down and would otherwise have been missed by the binder.

It was in this period, too, that another of our Agricultural Engineering Divisions had its beginnings. In 1926, work started on the development of a seed cotton drier at Tallulah, La.--the start of the research of the present-day Division of Mechanical Processing of Farm Products. This was an auspicious beginning because in 1928 the government was able to patent a seed cotton drier--a drier that has been improved through continuing research, registered in five further patents, the last one in 1940. Today, seed cotton driers are processing more than half of our annual cotton crop, adding to the value of every bale that is so processed as much as \$5 a bale. Each year this drier adds \$20 million to the income of cotton growers.

*Cotton
K.K.
ginning*

The man who was the key to this early success in cotton ginning work, and who has added to his reputation as an engineer through the years, is Charles A. Bennett, then and now, head of all cotton ginning engineering research of the U. S. Department of Agriculture. In 1931, construction work started on the Cotton Ginning Laboratory at Stoneville, Miss., with a grant from Congress of \$100,000. Bennett was placed in charge of the Laboratory, and under his guidance, it has become the seat of outstanding authority on gin operations and equipment. Each year hundreds of ginners, growers, and spinners from the United States and abroad, visit the laboratory to study the new developments and to secure technical advice and assistance. Since 1943 the Extension Service of the USDA has employed two extension specialists to carry the results of the laboratory research to State organizations and directly to the ginners. The states in the Cotton Belt now employ extension specialists trained at the Laboratory by our engineers and PMA cotton technologists to further the use of improved ginning equipment and methods. In addition to the seed cotton cleaner which was improved at the Laboratory with such outstanding success, the unit there has also developed the standard density press, a lint flue cleaner, and many gin modifications that have increased ginning efficiency and improved cotton quality.

Today there are more than 1,500 lint flue cleaners installed in cotton gins across the country, all modelled after the engineered development. These cleaners commonly improved cotton 1/3 to 1/2 grade, amounting to an additional \$5 million annually. A pneumatic system of conveying cotton seed to trucks or storage through small pipes reduced necessary power requirements for this job more than one-half--another development stemming from the U. S. Cotton Ginning Laboratory. More than 500 of these small pipe systems have been installed in commercial gins.

As the need for more ginning information concerned with the irrigated cotton of the Southwest and West became acute, a branch cotton ginning laboratory was established in 1948 at Mesilla Park, N.M. At that time, Victor L. Stedronsky, a long-time engineer at Stoneville, was placed in charge of the New Mexico laboratory, and Charles Merkel, another engineer with an outstanding service record, was put in charge of engineering work at the Stoneville laboratory. Bennett was placed in charge of the overall work of both laboratories. The Stoneville laboratory is shared with the Cotton Branch of the Production and Marketing Administration, which is carrying on cotton technology research, and the Mesilla Park branch is likewise operated cooperatively by the agricultural engineers, PMA, and the New Mexico Agricultural Experiment Station. In 1950, the cotton industry supplied some \$16,000 worth of ginning equipment, the state of Oklahoma supplied buildings and laboratories at Chickasha, and our Division of Mechanical Processing of Farm Products furnished engineers to carry on research at this new location.

The Bureau of Agricultural Engineering -

The year 1931 not only witnessed the construction of the original cotton ginning laboratory, but it also was the year that the expanding Division of Agricultural Engineering became a Bureau. McCrory, who had been chief of the Division, became Chief of the Bureau. There were five engineering divisions in the original bureau: Irrigation; Drainage and Soil Erosion Control; Mechanical Equipment; Structures; and Plans and Service.

W. W. McLaughlin, who had been a USDA irrigation engineer since the early days, became chief of this division; Lewis A. Jones became chief of the Drainage Division; Gray was chief of the Division of Mechanical Equipment; Ashby headed the Division of Structures; and Betts became chief of Plans and Service. Bennett was on special cotton-ginning assignment under McCrory's supervision, as was Boyd, who was carrying on studies which resulted in plans that led to the improvement of the physical characteristics of farms, to make them more efficient and more economically sound. Total appropriations topped \$500,000 for the first time, with a total of \$583,840.

The Division of Irrigation was engaged in experimental field and laboratory studies designed to improve the irrigation practices of the arid West. Chiefly, the work was directed along those lines that tended to result in the conservation of the limited supplies of water available for irrigation. They dealt with the determination of water requirements of crops, the development of methods and equipment for measuring water, conducting it to the farm, and applying it; and the determination of the best means of replenishing the water supply in the underground reservoirs. In addition, special projects dealt with the specific relation of irrigation and drainage to the health and growth of fruit trees, and further work was done with organizations interested in irrigation. Headquarters of the Division of Irrigation were at Berkley, Calif.

The Division of Drainage and Soil Erosion, as set up by McCrory, was concerned with the disposal of excess water from the standpoint of improving farm land. The activities of the Division were largely confined to securing experimental data, application of which tended to improve drainage practices. One important line of study, for example, concerned the experimental determination of the rate at which excess water must be removed to afford good drainage. Another concerned the durability of drain tile under various conditions.

In connection with soil erosion control, the Bureau carried on the engineering phases of the project. Their work included research with terraces, dams, and other devices that would slow the rate and volume of water runoff and thus prevent soil washing. Always to be considered in this work were the corresponding problems involved in operating tillage and harvesting machinery over the terraces.

Gray's Division of Mechanical Equipment carried on research aimed at determining the actual requirements of machinery as applied to agriculture. Studies came under three main headings: Those dealing with the application of machinery to particular crops, including fertilizer distributing machinery; the engineering problems involved in processing crops; and those concerned with mechanical means of combating insect pests. Sugar beets, cotton and corn production and harvesting machinery were getting research effort at the time the Bureau was set up. Studies were also being made on artificial dehydration of forage crops and small grains. The European corn borer was receiving the most attention of projects in the third category, although important work was underway in the control of the pink bollworm in cotton, and the development of more satisfactory equipment for spraying insecticides.

The Division of Structures, as described by McCrory in 1931, dealt with the fundamental problems of building construction and building equipment as related to the farm. Farm water supply, sewage, lighting, and heating also came under Ashby's direction.

Finally, the Division of Plans and Service, as set up under Betts, at the time the Bureau came into being, was concerned principally with the rendering of engineering and architectural services to other bureaus of the Department of Agriculture in connection with the design and construction of needed facilities. Plans and Service prepared plans and specifications for structures and for equipment to be used in the structures, made surveys and maps, and supervised construction work.

During the eight years that the Bureau of Agricultural Engineering existed, research was continued along many old lines, and many new projects were instituted. During this period Hukill and W. P. Greene developed instruments that could be used to measure the heat of respiration of common fruits and

vegetables. J. R. McCalmont made some important discoveries concerned with the pressure of ear corn on walls, floors, and cross bracing of corncribs-- facts that have led to the current design of these structures. McCalmont also determined the pressure exerted by silage of different moisture contents against the walls of different capacity silos.

C. F. Kelly headed a project to determine the limited moisture content for safe storage of wheat under different climatic conditions. His group of research workers also determined the effect of various structural types of storages and ventilation methods for keeping wheat from spoiling under all kinds of weather. Kelly also carried out preliminary work in drying grain with heat.

Interest in farmhousing generally was revived in 1931 when President Herbert Hoover called a conference on housing and home ownership. This brought many of the interested parties together and brought out valuable information that formed a basis for future research. In 1933, for the first time, the cooperative Plan Service became operative. Cooperating with State colleges, the American Society of Agricultural Engineers, and the U. S. Department of Agriculture published the "Midwest Plan Book," including some 50 farmhouses, plans of which were made available to farmers through their State Extension Service. This cooperative work not only eliminated the cost to the government of sending out thousands of blueprints each year, but improved service to farmers. The "Midwest Plan Book" was followed by the "Northeastern Plan Book" in 1937, the Western in 1939, and the Southern in 1940. The "Northeastern Plan Book" was revised in 1950.

Farm home research got a tremendous boost in 1934 when a survey of farmhousing was set up as a Federal civil works project. Some 631,000 farmhouses were included in the survey and from it came the knowledge of farmhouse conditions throughout the United States as well as the desires and needs of farm families. Funds from this project were made available for the preparation, in cooperation with 16 States, of a group of farmhouse plans published in Farmers' Bulletin No. 1738, "Farmhouse Plans."

Further farmhouse impetus came in this period when the Division of Structures carried out a field project on home remodelling with the University of Wisconsin. M. J. LaRock, and later O. E. Brunkow, studied the homes to be remodelled, helped the owners make the changes decided on, and determined the results after remodelling. Another approach to housing research was made by this Division through J. W. Simons, who cooperated with the University of Georgia. In this experiment eight small houses were built and studied in relation to temperature, and corresponding studies were made of occupied homes in the area. Two technical and two popular USDA housing publications have been issued including recommendations based on the research in these two studies.

In the period from 1933 to 1937, Japanese Beetle control machinery investigations were made. They were originally set up under the leadership of R. M. Merrill, who was in charge of all pest control machinery investigations. Later Irons and Young headed the Japanese beetle work. Tillage studies concerned with cotton production were begun in 1931 and ultimately led to the erection of the U. S. Tillage Machinery Laboratory at Auburn, Ala. in 1935. Here in nine soil bins, each 250 by 20 feet in length and width, and each containing 2 feet of soil of a different type, critical studies of tillage machinery were begun. The only laboratory of this sort in the world, it was first headed by John W. Randolph. ***

Merrill succeeded Randolph in 1937 when the latter took charge of a sweet-potato machinery project, and he headed the tillage work until 1942 when he was asked to serve with the War Production Board. During 1938 to 1941, the investigations at the Tillage Machinery Laboratory were redirected to national defense projects. The personnel and the shop facilities were used in the development of equipment for the production, harvesting, and handling of oil bearing crops, and the War Department, in cooperation with our group, conducted flotation studies of ordnance equipment. Some of the beach landings made in the war with Japan were facilitated by the use of devices and attachments developed at this laboratory.

I. F. Reed took charge of the work in 1942 and in 1950, when Reed was chosen to head research in oil crop machinery, Dr. E. G. McKibben was placed in charge of the tillage laboratory studies. From research carried on at the laboratory, manufacturers of tillage equipment have learned about designs and materials that make good implements, which has helped them in the design of successful new farm tools. Since 1935, when the laboratory first went into operation, more than 13,000 tests have been made with such equipment as moldboard and disc plows, rotary tillers, disc coulters, middlebreakers, and subsoilers. The tests have resulted in implements of improved design, reaching the farm in usable form in a minimum of time, and have relieved manufacturers of much of the time and money-consuming experimenting with various designs of their implements.

More recently, extensive work with tractor tires has set the stage for more efficient tractor operation on farms across the country. Research that is establishing recommended practices on tire inflation, weighting, rim width, and tread design will help individual farmers save many gallons of fuel a year, while doing more work with their machinery.

During this same period studies concerned with the utilization and cost of farm power in the Yazoo Delta of the Cotton Belt and in the Corn Belt were carried cooperatively under the direction of W. M. Hurst, now with the Division of Mechanical Processing of Farm Products, and the late W. R. Humphries. Hurst also had studies underway concerned with the mechanical

harvesting and drying of rice and small grains at this time. Results of these studies were published in Circular 127, "Grain Drying at a Country Elevator", Circular 292, "Artificial Drying of Rice on the Farm." The research highlighted the importance of intermittent drying for maintaining high quality of rice, a practice which has been followed since that time.

Corn production studies, which were to lead to vast improvements in the modern picker and mechanical harvester were instituted in 1931 under the leadership of C. K. Shedd. Planters and cultivators were likewise improved through this research.

Also begun in 1931 were investigations of spray and dusting equipment concerned with the control of pecan insects and plant disease, under the guidance of E. M. Dieffenbach. Limited studies with sweetpotato harvesting machinery were started in 1937 under Hurst's direction.

Although engineering research continued to expand through this period with additional projects begun in Land Operating Efficiency in 1935, Agricultural Fires and Dust Explosions in 1938, Flood Control and Waterway Investigations through 1934 and 1935, the Bureau of Agricultural Engineering suffered a major loss in 1938 when the Divisions of Farm Irrigation, and Farm Drainage and Erosion Control were absorbed by the recently organized Soil Conservation Service, to serve as the nucleus of its research section.

The Bureau of Agricultural Chemistry and Engineering -

In 1939,,Secretary of Agriculture Henry Wallace, for reasons which were not announced, dissolved the Bureau of Agricultural Engineering and combined the engineering work with chemistry research in the Bureau of Agricultural Chemistry and Engineering. Dr. Henry C. Knight was Chief of the Bureau and McCrory became an Assistant Chief.

* As the Bureau bowed out, however, it established a new Division of Farm Electrification, which since has become a strong member of the agricultural engineering research team. Lyle accepted the reins of this new post, transferring from the Extension Service, and he went right to work surveying the field in 1939 to determine the amount of electrification research that had been conducted by the State agricultural experiment stations. Also during that year work was started in cooperation with four different states concerned with the development of new farm uses for electric power. Farm refrigeration, chick brooding, pig brooding, lighting for dairy barns, and heated drinking water were prominent among the electrification items gaining research attention. Lyle resigned his position as Division Head within a year of his appointment and H. L. Garver took over project leadership.

Appropriations for agricultural engineering research were less than \$400,000 during the years that the various Divisions of Agricultural Engineering were associated with the Bureau of Agricultural Chemistry. The engineers operated on this reduced basis from 1939 until 1944 when they were moved again, this time to the Bureau of Plant Industry and Soils. Losing two important divisions, shuttling from Bureau to Bureau, plus the devastating effect of World War II on the supply of agricultural engineers available for research, tended to limit engineering research to much the same pattern that had been established in previous years.

In 1941 Hukill began a study of apple and pear storage in Washington state which resulted in his recommendations for improving storage and handling of these fruits being published in USDA Circulars 740, "Cold Storage for Apples and Pears" and 759, "Coordinated Management for Harvesting, Storing, and Marketing Northwest Apples". It was necessary to discontinue this work in 1942 and assign Hukill to grain storage research.

Seven of the research engineers in the Structures Division went into the armed services and Ashby, Head of the Division was on special duty, first with the War Food Administration, later with the Hemp Division of the Commodity Credit Corporation. Several other engineers in the Structures Division -- including Simons, Brunkow, Edgar, and T.A.H. Miller -- were called on for emergency engineering duties.

The war took its toll on the newly established Division of Farm Electrification, but not before its personnel accomplished some excellent cooperative research work, especially in pig brooding. Their early work along this line had proved that brooding pigs under incandescent lamps could save more than an extra pig from every litter, and during the war brooding became a general practice on the farms of the Midwest. An egg cooling study in cooperation with the University of Virginia showed that cooling could increase the value of a dozen eggs by 1 or 2 cents. Tests with Purdue showed the value of refrigerated egg storage, measured both in quality and better market price.

Water warmers developed for hog and cattle stock water tanks before the war set the pattern for many of these items that have appeared on the farmers' market since the end of World War II. Two publications, F.B. 1838, "Electric Light for the Farmstead", and F. B. 1858, "Electric Motors for the Farm", made their appearance in 1940. A small, electrically operated cross-cut saw, developed in 1940 by Garver, who was in charge of the Division of Farm Electrification, in cooperation with Paul G. May of the School of Living, Suffern, N. Y. is still in wide demand. This unit, driven by a motor as small as 1/4 h.p., is operated by two men and will handle logs up to 15 inches in diameter.

In 1942 Farm Electrification projects were terminated for the duration of the war, excepting the cooperative project at the Virginia Agricultural Experiment Station. That work on egg cooling was continued until 1944 when it was changed to a research study of forage drying with forced ventilation. Gray, Head of the Farm Machinery Division supervised this work until the Division of Farm Electrification was re-established in 1946, with T. E. Hienton as its Head.

It was at this time, too, that the Division of Mechanical Processing of Farm Products began to take the form in which we know it today. Boyd, who had been Assistant Chief of the Bureau of Agricultural Engineering since 1932 took charge of the cotton ginning and flax fiber research and of the Plans and Service Division.

Flax research through this period included studies begun in 1939 looking forward to the development of better mechanical means of producing, harvesting, and processing fiber flax in the Willamette Valley in Oregon. Although this fiber crop was established there as early as 1844, little development in machinery for handling the crop was apparent until after the First World War. Hurst, who was assigned to this project in 1939, and his successor in 1945, Jesse E. Harmond, have done much to put the flax fiber industry of Oregon back on an increasingly profitable business basis.

Enough progress had been made before the war to help in expanding the industry for supplying much needed fiber during hostilities. The availability of flax mill plans greatly speeded up the financing and construction of new plants. From 1940 to 1943 the number of processing plants, most of them using some new equipment developed through research grew from four to 14.

One of the most valuable research contributions has been the rotary comb de-seeder, the use of which has reduced labor requirement from 10 to three man-hours per ton of pulled flax. There are several of these machines in use, saving more than \$50,000 in labor costs each year. A better scutching machine has raised the yield of line fiber about 2 percent -- \$10 a ton when measured in terms of the farmers' delivered receipts. Fiber flax tow, once a worthless by-product of the Oregon flax mills, has gained worth with the development through research of tow cleaning equipment. One mill made their worthless tow return \$70,000.

This division also began to investigate special fiber crops in 1943 to assist the war effort. At first this work was aimed at utilizing sansevieria fiber, and later the War Production Board made funds available for research on ramie. This project was cooperative with the Florida Agricultural Experiment Station. Kenaf also came into the picture after the war, as a possible substitute for the scarce jute fibers. Mills H. Byrom has been in charge of this project since its beginning and his work is leading to the development of handling and processing equipment that will make it economically feasible to grow and industrialize the processing of these important fiber crops in the United States. Currently most of our fibers for binder twine, burlaps, and rope are imported.

Harmond also carried out the engineering functions of cooperative food compression research during the war years. The Agricultural Research Administration of USDA headed dehydrated food compression research from 1943 to 1944, under a grant from the War Production Board. The aim of the project was to determine the feasibility of reducing the bulk of the various products by compression into block form, and thus save storage and shipping space. A further object was to determine the effect of compression on the storage life and table quality of the food. Termination of the work as War Production Board funds were used up, prevented the carrying out of a well-rounded program. It is believed, however, that the groundwork has been laid for important work in this field and that the information gained is significant enough to warrant careful consideration of future possibilities in food compression.

From 1942 to 1944, emergency rubber projects, aimed at filling war needs, were conducted cooperatively with the Forest Service and the Bureau of Plant Industry. Three crops were investigated as sources of rubber--guayule, goldenrod, and kok-saghyz (Russian dandelion). The agricultural engineers were called upon to develop production and harvesting equipment for all three.

Originally, production and harvesting equipment for guayule was investigated at Salinas, Calif. Several types of commercial transplanters for transplanting guayule seedlings were adapted under direction of S. W. McBirney.

A four-row harvester for field scale guayule seed harvesting and a two-row machine for plot seed harvesting were developed. A shrub plow was devised for harvesting the guayule plant. For baling the shrub for storing, a baler with a vertical and unusually large baling chamber was adapted for the purpose.

Goldenrod production and harvesting equipment studies were initiated with headquarters at Waynesboro, Ga., under the direction of E. D. Gordon. For transplanting stolen cuttings a manual type transplanter was modified for the purpose. Planting was also accomplished by broadcasting with a slightly modified manure spreader. For harvesting first-year plantings of goldenrod, a power take-off driven corn binder performed satisfactorily but for succeeding years a grain binder was necessary because of the spread of the shoots and plants. Use was made of a spike-tooth thresher cylinder for stripping the leaves of the goldenrod.

Kok-saghyz production and harvesting equipment studies with headquarters at Beltsville were started with R. M. Ramp in charge of engineering. He found that regular vegetable crop seeders could be used for seeding vernalized kok-saghyz seed. The studies indicated that the pull-type, multiple-row truck crop cultivator was most accurate; that weeding knives are best adapted for cultivating mineral soil areas; and that disk cultivator tools are best adapted for peat and muck and poor scouring soils. Some eighty units of the four-row seed harvester developed on this project built for the Forest Service performed satisfactorily. For digging kok-saghyz roots modified potato diggers fitted with a special digging shovel and clod breaker were used. Two types of experimental toppers were developed.

Although all of this research added up to important contributions to the war effort, the most intensive research concerned the development of hemp production methods and facilities in the U.S. Almost our entire supply of Manila fiber and more than half of our supply of sisal were cut off by the war. The supply of jute from India was likewise threatened. To meet the shortage flax fiber production was increased in the limited area in which it is grown in the U. S. and the remnants of what had once been a sizable hemp production program in Kentucky and Wisconsin were again brought into focus. The problem of increasing hemp production fell on the shoulders of the Bureau of Plant Industry, the Commodity Credit Corporation and the research engineers. McCrory was made Director of the project, Boyd took over supervision of Agricultural Engineering Research, and Garver was

X assigned the job of designing and constructing hemp processing plants and harvesting machinery. J. Robert Dodge was chief architect. In all 42 processing plants were built at an average cost of \$297,000 each. These mills began producing hemp in late 1943 and during the short time they were in operation (until the end of the war) they produced about 150 million pounds of hemp fiber. Most of this fiber was used in making rope for the Navy, industry and for farm use. X

X In the meantime, many of the engineers in the Farm Machinery Division were called on to establish programs that would help to keep farm machinery in repair. Several of the engineers were assigned to the Office of Materials and Facilities to aid in the allocation of critical materials for use in machinery and buildings for agriculture. Engineers of this Division also worked on the development of equipment for hulling castor beans. They field tested binder twines of various compositions in a search for a substitute for hard-to-get twine. The plots and test equipment of the Tillage Machinery Laboratory at Auburn, Alabama were taken over by the Army during 1944-45 for flotation studies of ordnance equipment.

The Bureau of Plant Industry, Soils, and Agricultural Engineering

In 1944 agricultural engineering research was transferred to the Bureau of Plant Industry and Soils. Arthur W. Turner, of the International Harvester Company, was employed at that time as an assistant chief of the Bureau to head the agricultural engineering work. For the first year, the work was administered as a Division of Agricultural Engineering. In 1945, however, the Divisions regained their original identity with Gray heading the Division of Farm Power and Machinery, Ashby, the Division of Farm Buildings and Rural Housing, Boyd, the Division of Mechanical Processing of Farm Products and the Division of Plans and Services, and Hienton, formerly of Purdue University, and just back from military service, was brought in to head the reactivated Division of Farm Electrification.

Agricultural Engineering had reached a low financial ebb in 1944 receiving a smaller appropriation than at any time since 1929, but the downward turn was only temporary. In 1945 appropriations were up about \$150,000, up again in 1946, and by 1947 they had climbed about \$600,000.

The Division of Farm Buildings and Rural Housing strengthened their animal shelter work in 1946, carrying on cooperative dairy cattle research in the newly developed psychroenergetic laboratory at Columbia, Mo., and poultry housing work was initiated in two specially built calorimeters in 1946 at Beltsville, Md. Hog housing research was being conducted in a smaller psychroenergetic laboratory at Davis, Calif. All work was cooperative.

From this varied research is coming information on the best housing conditions for all types of livestock; information that is not only physiologically important as far as the animals are concerned, but that will provide valuable data for the design of future livestock structures. In addition, this division has carried out a study comparing bank and above-ground dairy barns in Wisconsin; another comparing stanchion and loose housing barns in Utah, and a third concerned with the physical and economic features of dairy buildings in Illinois.

The bank-barn study led to the modification of sanitation codes for dairymen, allowing more consideration for the operator with a bank barn; the second study has established the place of the loose housing barn, and the later research study is directed at a reduction of both investment expenses and labor requirements in the dairy buildings.

Crop drying and storage, which like farmhousing and livestock shelters had its early beginnings in research aimed at the development of building plans, has developed into one of our most important post-war

engineering projects. Potato, sweetpotato, apple and pear handling and storage have all been improved through research since the war, but the research affecting the widest area has been that concerned with storage and drying of corn and cereal crops. As each year brings further demands on our farmers to produce even more of these food and feed grains, it is more and more necessary that none that is grown is lost through spoilage or bad harvesting weather. The grain drying and storage research promises this saving--in fact, has already progressed far enough so that drying is becoming a fairly common practice throughout the Midwest. Long-time grain storage became an important factor at the outset of World War II, and in cooperation with the Commodity Credit Corporation and the Bureau of Entomology and Plant Quarantine, research engineers established two large scale experiments at CCC bin sites. These studies at Jamestown, No. Dak., and Hutchinson, Kans., showed the effect of various construction practices upon the efficiency of buildings as grain storages.

Similar work was carried on with the storage of shelled corn at CCC bin sites in Iowa and Illinois. Problems of moisture migration, grain cleaning, and bin construction were analyzed and solutions arrived at. Engineering aid has been given the Commodity Credit Corporation in all bin purchase programs, both in analysis of bids and through field inspections of structures during their erection.

Following the war, a study of grain and seed storage in the Southeastern States was begun in cooperation with the University of Georgia under the leadership of Simons. A drier using chemically dehydrated air was developed for use by farmers having small lots of seeds to dry, and a homemade oil-burning drier was devised for use with larger quantities of seeds.

The Research and Marketing Act of 1946 made it possible to undertake new phases of work on the conditioning of ear corn, small grain, and seeds. In 1947 the Agricultural Experiment Stations of Iowa, Indiana, and Illinois cooperated with USDA agricultural engineers in studies of drying ear corn with heated air, and in developing approved specifications for drying equipment. Later this work was expanded to include drying shelled corn, small grains, and seeds. Close contact between research and manufacturers has led to rapid improvement in drying equipment on the farmers' market.

Ashby, head of the Division of Farm Buildings and Rural Housing, expects this work to result in major changes in farm methods of harvesting and handling grain with corresponding changes in farm buildings. Hukill, Shedd, Benton Stahl, George Foster, and L. E. Holman are some of the men who have been closely associated with this progress.

Likewise, in the field of farm electrification, the forage drying research is beginning to pay off in tremendous benefits to the dairy and livestock farmer. Barn drying forage crops, developed through extensive research is offering dairymen and farmers a way to beat the weather hazard, and at the same time increase the feed value of their hay. Barn drying of forage crops is described in Farmers' Bulletin 2028, issued in 1951. One phase of this work--concerned with air movement through partially dried hay-- was initiated by Andy Hendrix in 1944 in cooperation with the Virginia Agricultural Experiment Station. Roy Davis took over the work in 1947 and V. H. Baker completed the project at that location in 1950. Another phase of the work was conducted at Beltsville, Md., beginning in 1945 and in cooperation with dairy and hay marketing specialists. This program included studies of harvesting, curing, and storage of forage as field-cured hay, forced-air dried hay, wilted silage, and dehydrated hay in relation to preservation of food value. Schoenleber headed this engineering research.

Final evaluation of the Beltsville phase of the research was made by feeding the variously cured forages to lots of dairy cows. The value of forced-air drying of forage to be cured as hay was revealed by one test in which relative milk production per acre of forage for forced-air dried hay was almost 50 percent greater than that of rain-damaged field-cured hay.

Bright-leaf tobacco curing research was initiated in 1946 in cooperation with the North Carolina Agricultural Experiment Station. Dr. O. A. Brown, who has headed the project since its beginning, has watched his efforts to improve curing methods and equipment enable tobacco farmers to reduce their curing cost 50 percent. The saving in cost of fuel for curing tobacco in North Carolina alone, by general adoption of these research findings would add up to a saving in excess of \$4-1/2 million a year.

Research developments combined with new safety regulations have helped reduce barn fires 350 percent from 1946 through 1949.

Investigational work on the curing of cigar tobacco was first undertaken by J. M. Stanley of the Division of Farm Electrification in 1948. Some cooperative work was done on the use of liquid petroleum gas as fuel for curing shade-grown tobacco in limited amounts in 1948 and increased in quantity the following year. This fuel has been adopted by many growers in the Georgia-Florida area to replace charcoal.

W. A. Junnilla conducted comparative tests of lp gas and charcoal for curing shade-grown tobacco in Connecticut in 1950 on a more extensive scale. Resulting differences in the value of the tobacco so greatly favored that cured with gas---45 cents per pound---that one-third of the acreage grown in the Connecticut Valley this year is being cured with that fuel.

Two modified short-time electric milk pasteurizers, designed primarily for individual farm use, were developed in cooperative investigations by Junnila in 1947 and 1948. These were developed to meet the need for an electric pasteurizer which would do an effective job in a short time and would satisfy the standards of the U. S. Public Health Service. The low-wattage, short-time pasteurizer, developed in this project, has been in commercial production since 1948, and is providing protection for many farm families from the danger of undulant fever.

Cooperative electrification studies with the Purdue University Experiment Station were interrupted by World War II, but were resumed early in 1947 with the appointment of John G. Taylor to the project. Combined laboratory and field tests in 1947-8 determined the maximum attractive intensities to the corn borer moth to be in the near-ultra-violet range. Tests with lamps of these intensities in Indiana in 1948 not only caught corn borer moths but also those of serious tobacco pests--the tobacco and tomato hornworms. As a result a single trap was tried in North Carolina in 1949 by Dr. Brown with surprisingly good results. The research was enlarged in 1950, and in 1951 power companies cooperated to install about 30 traps of a new research design on tobacco farms in Virginia, West Virginia, North Carolina, and Georgia. Exploratory studies on use of electric traps were initiated in 1951 on cotton insects in Georgia and Texas and on the sugarcane borer in Louisiana. Iowa has been cooperating in corn borer trapping work since 1949.

The Division was invited by the Bureau of Animal Industry in 1946 to participate in a study already under way on the effects of bactericidal radiation on airborne diseases in poultry. Unexpectedly the irradiated birds produced from 10 to 19 percent more eggs in five consecutive test years. The project has been revised to determine the effects of such ultraviolet radiation on the health and production of birds from hatching through two or more years after maturity. Comparable tests to those in the underground house are being made in houses in common use.

Exploratory studies with ultrasonic energy generated by a machine equipped with piezo-electric quartz crystals were initiated in 1947. This work has been limited chiefly to such applications as effects on insects and effects on seeds. Mosquito larvae have been killed with a 5-second exposure. Seed viability can be destroyed by such treatment but some evidence on treatment of seeds of hybrid corn in 1950 indicates that yields may be increased. Further work on hybrid corn is in progress.

Cooperative investigations with the Kansas Agricultural and Engineering Experiment Stations on the heat pump were initiated in 1949. Research has been concentrated on determining the rate at which heat moves through various types of soil under varying moisture conditions. Records have been obtained on both heating and cooling during 1949, 1950, and 1951 on the operation of three heat pumps installed in farm houses near Hutchinson.

Walk-in type farm refrigerator freezers and electric beehive heating are also under study.

X In late 1947, investigations were started in the Pacific Northwest by Division of Farm Machinery engineers on the development of airplane and ground spraying and dusting equipment for applying insecticides to control pea aphids.

Since 1948 D. A. Isler of the Division of Farm Machinery has cooperated with the Forest Insects Division of the Bureau of Entomology and Plant Quarantine at Beltsville, Md., developing aerial insecticide spraying equipment.

In 1949, work was started at College Park, Md., and the development of a ground DDT sprayer for controlling corn earworms, corn borers, and Japanese beetles in canning corn. The sprayer was so effective that processors using it were able to speed up their canning processes as much as 100 percent in some cases. Spraying gained canners an extra three to four cases of cannable corn from every ton and cut the cost of trimming--a handlabor job--by one-third.

Although research agricultural engineers had worked sporadically since 1917 with other federal agencies on airplane distribution of dusts and sprays there had never been an opportunity for controlled engineering design and evaluation of aerial dispersal equipment. In 1949, representatives of various agencies, including the agricultural engineers, met with representatives from the Civil Aeronautics Administration, the National Flying Farmers Association, and Texas A. and M. College to plan a cooperative project at the Texas institution. As a result, an experimental agricultural airplane, the first of its kind, has been designed, built, and test flown. Agricultural engineers contributed to the specifications of performance characteristics and to the fuselage design to permit the installation of dispersal equipment for the experimental airplane, including spraying, dusting, seeding, and fertilizing equipment.

More than 1,700 individuals and firms are on record as doing agricultural custom work. Six thousand pilots have special licenses for such work and more than 7,000 airplanes are approved for such use. In 1950, more than 14 million acres of agricultural land in the United States were flown for some type of farm productive purpose.. The airplane has become an agricultural implement.

The Pesticide and Application Equipment Committee, an informal liaison committee with representatives from the National Agricultural Chemicals Association, the power sprayer section of the Farm Equipment Institute, and the National Sprayer and Duster Association, sponsored a cooperative research study on the prevention of pesticide chemical corrosion on application equipment with the Division of Farm Machinery in 1951. These groups have contributed nearly \$9,000 to carry forward this work.

A planting disc and rod-type middle harvester for sweetpotatoes, developed by Joe Park of the Farm Machinery Division in cooperation with the South Carolina Agricultural Experiment Station, has had wide acceptance by growers. This experimental work was begun in 1937 in cooperation with the Mississippi Agricultural Experiment Station, and was shifted to South Carolina in 1946. The project was terminated in 1951 when personnel and funds were shifted to a forage and legume seed harvesting project. It is expected that other divisions of the Bureau will cooperate with the Division of Farm Machinery in developing a pasture improvement program.

A weed control machinery project, carried out from 1937 to 1939 under the leadership of Dieffenbach, failed to get the support of the public and investigations were dropped because of a lack of funds. However, under terms of the Research and Marketing Act of 1946, a nation-wide program of weed control was set up in 1948. McBirney took charge of this research in 1951.

Peanut machinery research, begun in 1942, resulted in the development of both a peanut sheller and a peanut harvester that have since been adapted to commercial design. The experimental harvester, completed in 1949, shows exceptional promise. The machine can dig, clean, vine, stem, and bag an acre of peanuts in an hour. It cuts out tedious hand-stacking--a job that normally takes 30 to 35 hours of man labor per acre. It also will handle windrowed peanuts, combining two acres an hour from a windrow of four rows. Limited studies on castor bean and tung were started in 1943, resulting in an experimental tung nut huller and a castor bean huller. Although the castor bean work was discontinued after the war, the tung work went ahead, since 1950 at new headquarters in Poplarville, Miss., the heart of the tung growing area. Castor bean research was reactivated in 1950 in deference to our defense effort and Farm Machinery engineers have developed a stripper-harvester, 60 of which were used to harvest the 1951 crop.

In 1944, a sugarcane production and harvesting machinery project was inaugurated at Houma, La., under the leadership of R. M. Ramp. In 1946, cotton production and harvesting machinery investigations were initiated at Stoneville, Miss. with W. M. Meek in charge. In 1947, this project was reorganized as a cotton mechanization project and expanded to include Okla., South Carolina, Alabama, Texas, and California as well as Mississippi.

Coordinating our research on Southern states cotton mechanization research is R. F. Colwick. Engineering research has thus far provided improvements in every phase of cotton production. They have developed equipment which applies insecticides to cotton as it is cultivated, thus reducing spray costs to as little as 25 cents an acre. They have also developed special knives that adapt rolling stalk cutters to do a better job of seed bed preparation. Equipment has been designed that will

apply anhydrous ammonia fertilizer at the same time the cotton seed bed is prepared, and from a harvest standpoint, they have designed a cotton stripper employing revolving brushes, which may provide cheaper and better harvesting in some parts of the cotton belt. Three manufacturers are currently testing this machine. Laboratory work, recently completed by the engineers, indicates that present day planters may be modified to precision plant delinted cotton seed, thus insuring better stands, requiring less thinning.

In 1948, potato harvesting and handling research was initiated with headquarters at East Grand Forks, Minn. This work is sponsored by the Red River Valley Potato Growers Assoc. and is in cooperation with Minnesota and North Dakota Agricultural Experiment Stations. A. H. Graves is in charge of the farm machinery investigations.

Research at Grand Forks is carried on at a 320-acre farm and in laboratory buildings furnished by the Red River Valley Potato Growers Association. The Association spent nearly \$150,000 in setting up these research facilities.

As electric power and mechanization have become prominent throughout the country, they have made possible the development of many rural industries associated directly or indirectly with agriculture. Such enterprises open up great opportunities for farmers to increase profits, balance labor requirements, and generally improve their standard of living. The majority of such activities, such as locker plants and associated processing operations, poultry dressing plants, farmers' markets, and feed grinding and mixing plants, develop as a result of local interest and initiative. These activities are now widespread and of sizable proportions.

In 1945 the Farm Credit Administration requested assistance in conducting studies of an engineering nature of processing and marketing activities carried on by farmers' cooperatives and Hurst was given this assignment. In 1948 George A. Amacker was assigned to the project and E.G. Grab in 1949. Activities have included studies of poultry dressing plants, farmers' produce markets, feed manufacturing plants and operations, cheddar and granular cheese making, consolidation of oil milling and cotton ginning enterprises, and fertilizer manufacturing plants.

In 1948, funds were made available to the Division of Mechanical Processing of Farm Products under the Research and Marketing Act of 1946 for improvement of processing facilities and equipment for rural plants for processing farm products. Work under this project was started in cooperation with the University of Georgia dealing with the development of improved processing equipment for locker plants, community canneries, feed mills, and fence-post peeling and treating equipment. Off-farm employment was needed in rural areas in the Southeast because of farm mechanization and the increase in producing grain crops, poultry and livestock had created the need for new developments and the adaptation of plants and equipment to conditions peculiar to the South.

The Georgia investigations brought out the possibilities for industrial engineering application to agriculture and for developing small-scale processing equipment for rural plants regardless of geographic location. The work was expanded in 1948 to include the processing of fruits and vegetables in Michigan, and poultry processing in New Jersey in 1950. Hurst has been in charge of the project, assisted by William M. Bruce at Athens, Ga., J. H. Levin and H. P. Gaston, East Lansing, Mich., and B. C. Haynes, Jr., New Brunswick, N.J.

Plot plan and floor plan layouts for increasing labor efficiency in fruit packing shed, locker plant kitchens, community canneries, poultry dressing plants, farmers' markets, and feed mills have been used in altering existing plants or in building new ones. Machinery developments or improvements in existing machines for locker plants or community cannery use include: pea and bean sheller, corn cutter, corn desilker, carton filler, washers, and blanching equipment. A pea and bean sheller, corn cutter, and desilker based on laboratory developments have been placed on the market.

Studies of grading, sorting and packing operations in Michigan apple packing sheds led to the conclusion that field grading would have advantages in some orchards. A grader was adapted for moving from one "set" to another in the orchard and studies made of its performance. Possible advantages of field grading in many Michigan orchards include: less handling and better supervision resulting in less bruising, reduced handling of under-grade fruit, increased picker output, reduced packinghouse space requirements, and increased storage life of apples. The monetary value of these items amounted to nearly 17 cents per bushel in one orchard where the machine was tried out in 1950. As a result of the findings three manufacturers of fruit-handling equipment have placed field graders on the market.

A hand-operated mechanical aid has been developed for dumping fruit on the grader receiving line at packing plants. The machine makes the dumper's job easier, facilitates control in the flow of fruit to the sizer, and reduces bruising. With the dumper the apples flow onto the receiving belt without significant drop. Actual counts show that by using the dumper 60 to 70 percent of the bruising that otherwise occurs at this point can be eliminated.

Plans and Service Division is Discontinued -

The Construction program of the Department of Agriculture for the Fiscal Year 1952 was wiped out entirely because of the Defense program. This made it necessary to disband the Plans and Service Division at least for the time being.

Almost from the establishment of engineering work in the Department of Agriculture the engineers have been called upon to give assistance to the Department in planning and erecting its buildings outside of the District of Columbia. In the years since the work first began in 1926 a tremendous amount of construction work has been planned and constructed by the organization which has come to be known as the Division of Plans and Service.

The list of projects is a long one including a wide variety of structures. The list includes all of the buildings at the Agricultural Research Center and the Plant Industry Station at Beltsville, Md., the four Regional Laboratories, each of which, with its equipment, cost about \$2,000,000.00, and all of the Federally owned buildings at field stations. Through the Office of Foreign Agricultural Relations the Division has also planned and built many experimental stations in Latin America, such as those at Tingo Maria, Peru; Turrialba, Costa Rica; and designed agricultural college buildings for Mexico and Venezuela.

There never were any appropriated funds for this work so that it was necessary to do it on a reimbursable basis. Consequently, there was no opportunity for advanced planning and the number of people employed varied with the amount of work on hand from month to month. During the peak period of employment there have been as many as 300 engineers and architects employed, while during slack times the number had to be curtailed to suit the amount of work on hand.

In the early days Betts was in direct charge of this work. When Boyd came to Washington as Assistant Chief of the Bureau of Agricultural Engineering in 1932 he took over the general direction of this project and has had this responsibility continuously since that time. Under Boyd's direction, Joseph A. Scott was Chief of the Division from 1936 to 1940 and since that time the responsibility was carried by Walter G. Cadmus, Jr., and Charles E. Taylor.

The Present Status of Agricultural Engineering Research -

Thus we come up to date--1951. Our appropriations for 1952 total \$1,310,850. There are 121 professional employees associated with the four research divisions of Agricultural Engineering. This, a year of national effort toward the defense of our country, has seen all of our research evaluated for its timeliness and potential contribution to the current need.

Much of our research is playing an important role in the success of the national program. Other long-time research will advance through this year, resulting in a better rural economy, in the years ahead. High production with little labor is the goal of farming in America and the Agricultural research engineers are playing a leading part. High producing, labor-saving machinery for many important crops is under experiment. Handling and storage research is saving a bigger percentage of our crops each year with less work and higher quality. Better processing, through research, is adding quantity and quality to the output of important farm products, and is also carrying forward a program of providing this country with materials often hard to get in time of war.

The role of the agricultural engineer in importance to our democracy has been ever upward. The man who in 1904 was defined by a group of educators as one who practices the science and art of laying out farms, designing and constructing farm buildings and works, and making and using farm implements, has accepted those responsibilities and a lot more.

Today the complexities of research require that the agricultural engineer be a highly trained and specialized scientist. The modern agricultural engineer is expected to apply the mathematical, physical, and engineering sciences to all the various phases and ramifications of the agricultural industry. Also he must give consideration to the other sciences and technologies which are fundamental to agriculture--the biological, chemical, and soil and economic sciences. He applies his knowledge and science not only to the point of primary production--the farm--but also to the engineering phases involved in supplying essential goods and services to the farm, for maintaining comfortable and healthful living and working conditions for rural populations, and for facilitating the mechanical processing, storing, transporting, and marketing of agricultural commodities, until they reach the buyer.

Specifically, research agricultural engineers in the U. S. Department of Agriculture are neither mechanics nor commercial designers. Their primary objective is to determine new physical principles, techniques or specifications for improvements within the area of their responsibility. In order to prove the effectiveness of their ideas, they usually must build a machine, structure or other piece of equipment to test it under the full range of actual working conditions. Some of these may be simple, permitting an individual to build the new unit for his own use or to modify or adapt existing equipment to the new specifications. In most cases, the Federal research agricultural engineer will rely upon the cooperation of research engineers in industry to redesign the new unit for commercial production, retaining the essential features of the research development. By securing the inherent economics of commercial mass production, the research findings can be made available to farmers more quickly, at lower cost, and with less effort than by individual contacts.

